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Original

The Effect of Touching a Dolphin on the EEG Slow Waves in Children

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Abstract : Among animal-facilitated therapies, dolphin-facilitated therapy has been shown to beneficially affect human behavior, emotion and speech ability. We recently showed that touching a dolphin reduced the respiratory rate and state anxiety in healthy children. In this study, we collected electroencephalographic data (EEG), widely used for examining various brain functions, before and after touching dolphins. We examined the relationship between EEG power spectra and individual trait anxiety scores. The results showed that the appearance of slow waves in the frontal area increased significantly after touching a dolphin. Furthermore, the difference in slow wave activity was negatively, but significantly, correlated with trait anxiety in the frontal area. This negative correlation showed that slow wave power was greater in subjects with lower trait anxiety, indicating that touching a dolphin may be more effective for subjects with low trait anxiety than those with high trait anxiety. However, even though the increase in slow wave power was lower in subjects with high trait anxiety, touching a dolphin appeared to affect brain rhythms by increasing slow waves.

Key words : dolphin-facilitated therapy, electroencephalography, trait anxiety, slow waves

Introduction

Recently, the use of animal-facilitated therapy has become widespread. Higher survival rates have been observed in patients with heart failure who are pet owners compared to those who are not[1]. Dog owners are motivated to take daily walks and respond to stress more effectively[2]. It has also been reported that living with a pet decreases blood pressure and stabilizes the heart rate[3]. As a type of animal-facilitated therapy, dolphin-assisted therapy has been shown to have positive effects on human behavior, emotion and speech ability in autistic children[4,5]. We recently showed that touching a dolphin reduced the respiratory

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rate and state anxiety in children without psychiatric disorders[6]. Animal-facilitated therapy primarily affects the subjective experience of emotion.

Electroencephalography (EEG) has been widely used for the diagnosis of various brain diseases and also for examining various brain functions. Many studies have investigated the relationship between psychological changes and frequencies of EEG waveforms. One study showed that slow waves in the theta (θ) and alpha (α) band increased during dolphin-facilitated therapy[7].

In this study, we examined the regional distribution of slow waves (θ and α) in the frontal, central and parietal regions of the brain. We also examined the relationship between EEG power spectra and TRAIT anxiety scores.

Methods

Subjects

Six healthy children aged 7–10 years without any psychiatric disorders participated in this study, similar to the subjects in our 2008 study[6]. All children were unaware of the purpose of the experiment, and informed consent was obtained from each subject and their parents. The study was approved by the Ethics Committee of Showa University School of Medicine.

Experiments were performed at a dolphin pool in the bay of Ito City (Dolphin Fantasy), as previously described[6]. Under the direction of the dolphin trainer, subjects were asked to touch a dolphin.

Anxiety levels for each subject were evaluated by the STATE-TRAIT Anxiety Inventory (STAI)[8]. We used the STAI modified for children and translated into Japanese (Sankyoubou, Kyoto, Japan). The STAI is self-administered and consists of two anxiety scores: TRAIT and STATE. In this study, we used the TRAIT score, which reflects a general tendency toward anxiety and is not usually influenced by a particular activity or situation.

An electrode cap for children, with 19 electrodes placed according to the international 10–20 system, was used to record the EEG (IEC-SD Nihon Koden, Tokyo, Japan). Reference electrodes were placed bilaterally on the earlobes. Two other electrodes were placed on the face near the eyes to measure eye movements. EEG activities were sent wirelessly using a telemetric system (WEE-1000 Nihon Koden, Tokyo, Japan). EEG signals were measured and stored in a digital EEG analyzer (EEG-9100 Nihon Koden, Tokyo, Japan). EEG signals were sampled at 200 Hz through a 0.016–30 Hz bandpass filter. Electrode impedance was kept below 10 Ω.

The EEG power spectum for each subject was calculated as they remained still while touching a dolphin and while resting after touching a dolphin. Spectral power was analyzed by fast Fourier transformation (spectral analysis) with EEG analysis software (EEG Focus, version 2.1; Nihon Koden, Tokyo, Japan). Percentages of slow waves ($\theta + \alpha$) and faster beta (β) waves in the power spectra were compared during (During contact) and after (Post-contact) touching a dolphin.

Table 1. Mean percentages for all 6 subjects of the appearance of the slow wave ($\theta + \alpha$) in the frontal area (F3 + F4 + Fz), central area (C3 + C4 + Cz) and posterior area (P3 + P4 + Pz) during (During Touching) and after touching dolphin (Post-Touching).

	During	Post	During vs. Post
FRONTAL	55.5 ± 6.7	59.3 ± 3.5	$P < 0.05$
CENTRAL	58.6 ± 6.5	62.3 ± 5.3	N.S
POSTERIOR	55.9 ± 7.4	59.1 ± 6.6	N.S

All statistical analyses were performed with a commercially available statistical package (SPSS, Ver.11.0 ; SPSS, Tokyo, Japan). Differences between power spectra during touching a dolphin and during the rest period after touching the dolphin were analyzed by a one-way repeated measures analysis of variance (ANOVA). Correlation coefficients for the linear regression between differences of slow waves in the power spectra During Contact or Post-Contact, and trait anxiety scores were calculated.

Results

Table 1 shows the mean percentages for all six subjects of the appearance of slow waves ($\theta + \alpha$) in the frontal area (F3 + F4 + Fz), central area (C3 + C4 + Cz) and posterior area (P3 + P4 + Pz) During Contact and Post-Contact. The mean percentages in the frontal, central and posterior areas before touching a dolphin were 62.5 ± 7.7 %, 65.5 ± 5.3 % and 63.6 ± 5.5%, respectively. The mean "before" percentages were significantly higher than those During Contact ; however, the mean percentages in the frontal and central areas were not significantly higher than those Post-Contact, except for in the posterior area.

The mean percentage of slow waves in the frontal area During Contact was 55.5 ± 6.7 %, which was significantly lower ($P < 0.05$) than the Post-Contact result of 59.3 ± 3.5 %. The mean percentages of slow waves in the central area During Contact and Post-Contact were 58.6 ± 6.5% and 62.3 ± 5.3%, respectively, which were not significantly different. The mean percentages of slow waves in the posterior area During Contact and Post-Contact were 55.9 ± 7.4% and 59.1 ± 6.6%, respectively, which were not significantly different.

The relationship between the difference in wave power Post-Contact compared to During Contact (P-D / diff) and trait anxiety scores is shown in Fig. 1. The P-D / diff was negatively correlated with trait anxiety scores ($P < 0.05$) in the frontal area. However, correlations in the central and posterior areas were not significant.

Discussion

We examined the effect of touching a dolphin on the appearance and regional differences of EEG slow theta and alpha waves in healthy children. The results showed that the appearance of slow waves in the frontal area was significantly increased after touching

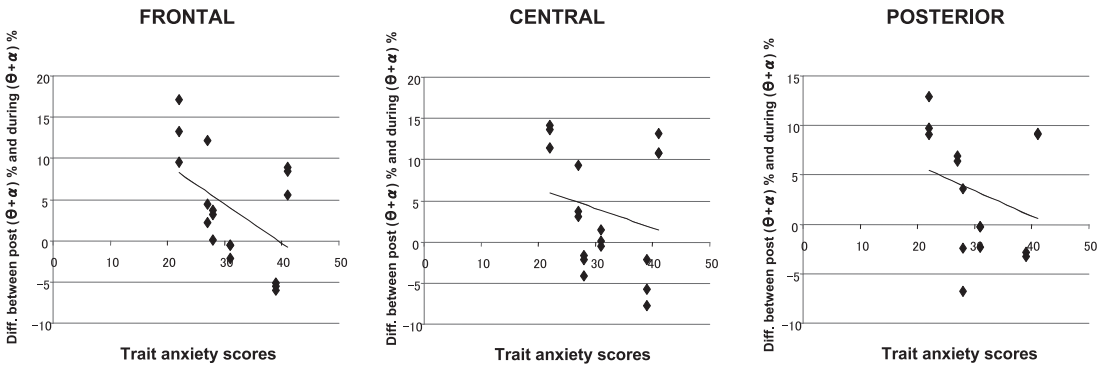

Fig. 1. Relationship between the difference of slow wave ($\theta + \alpha$) percentages during and after touching a dolphin and trait anxiety scores. FRONTAL : frontal regions of the brain ; CENTRAL : central regions of the brain ; POSTERIOR : posterior regions of the brain.

a dolphin compared to measurements recorded during contact with a dolphin. In addition, the difference in the percentage of slow waves during and after touching a dolphin was significantly correlated with trait anxiety in the frontal area.

EEG theta and alpha waves have been analyzed widely to demonstrate correlations with many psychological or emotional tasks and cortical information processing[9]. The power spectrum of each wave has been used to compare the strength of responses to various tasks[10]. Regional differences in the power for each wave may correspond to the activated cortical area and strength of the task. One study showed a tendency for more alpha power in migraine patients in all areas except F4 and C3, compared to healthy subjects[11]. Furthermore, decreased alpha activity was observed in the frontal cortex. De Bergerac[7] reported that theta and alpha waves are increased during dolphin-facilitated therapy. Increased slow waves may correspond to relaxation. In this study, we showed that slow wave power was significantly increased in the frontal cortical area after touching a dolphin. Our previous research has shown that subjects were relaxed after touching a dolphin[6]. This finding may correspond to the increased power of slow waves.

Results showing a significant correlation between the difference in slow waves during and after touching a dolphin and trait anxiety scores in the frontal cortical areas suggest that an increase in slow wave power may correspond to emotional changes, in particular, a feeling of relaxation. We showed that the slow wave power was significantly higher after touching a dolphin in the frontal cortical area than before touching a dolphin. Our previous study not only showed that subjects were relaxed after touching a dolphin, but also showed that state anxiety scores of the subjects decreased[6]. This may also correspond to the higher power of slow waves.

The negative correlation between the difference in slow waves during and after touching a dolphin and trait anxiety scores suggests that slow wave power was higher in subjects with lower trait anxiety. Overall, touching dolphins may affect emotional change and cause

an increase in slow waves. In particular, touching dolphins appears to be more effective in individuals with low trait anxiety.

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